Gulls following a boat soar in certain difinite areas with respect to the boat. It seems probable that some of the air eddies, that are caused by the boat's motion through the air and the accompanying wind together with the heated air that escapes from the engine room and funnels and streams *backward* and *upward*, may result in small areas where there are upward eurrents that are suffieiently strong and persistent to support birds for a longer or shorter distanee.

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QUARTERING FLIGHT IN MIGRATION

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By quartering flight is meant flight not directly against the wind, but rather at a substantial angle with the wind, perhaps fifteen to forty degrees. That such flight exists in nature is shown by the observations of Lynds Jones (1) on Hummingbirds flying from Pelee Island to Middle Bass Island in Lake Erie. It is also shown by William Beebes' notes on the Albatross (2). A. H. Clark (3) mentions the direction of the migration of the Golden Plover as being not in a direct line to the destination but aeross prevailing southwesterly winds along the northern part of their journey. However this last observation may be due to the faet that many birds tend to begin their migration during a period of high barometer (4). The direetion of the winds in such an area of high air pressure being cloekwise the migration routes in the area covered by the average northeasterly moving "high" would tend toward the eastward in the fall and toward the westward in the spring (5). (6). One of the most complete aeeounts of the flight of flying fishes is that by Holland (7) who states that the flight is at an angle with the wind.

Somewhat analogous is the taeking of a sailboat advaneing against the wind by using the foree of the same wind acting against the resistanee of the boat to the water. See Headley (10), page 8. Perhaps in the case of the bird the resistance is furnished by pulsating air eurrents. Pulsating air eurrents are discussed by Wolfgang Klemperer (8), who in a letter to the writer dated December 20, 1929, mentions the Knoller-Betz theory of pulsating air eurrents. (9), (11), (12). Variations in wind velocity are also diseussed by Otto Lilienthal (13): by Huffaker (14); by Hankin (15) who mentions "a form of air motion that blows a feather to leeward at one speed and blows the

complete bird to windward at another and greater speed"; by Maxim (16); by Dreisch (17); and by Langley (18).

It appears that birds wishing to take advantage of quartering flight fly at low elevations, particularly over the water, where air pulsations are caused by wave motion of the water. As shown by airplane experience, the air becomes quieter with increasing elevation. Over the cloud level few if any "bumps" are encountered and the air is usually quiet except when air strata moving in different directions meet, though the velocity relative to the earth increases with altitude. Probably therefore quartering flight is not common at the higher elevations and birds as well as airplanes travel in the upper air currents

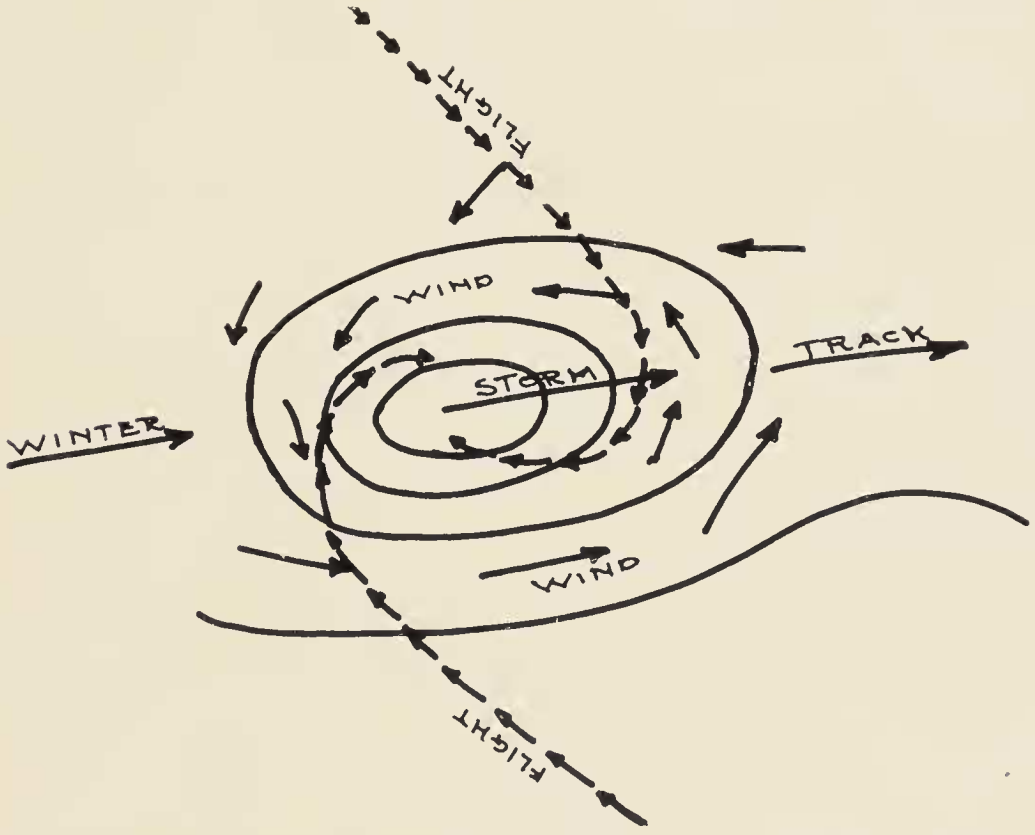

Fig 7. Diagram to show the effects on birds of quartering flight in a storm.

for the advantage of the increased velocity resulting from a favorable tail wind.

Wing areas apparently determine the character of flight, the Hummingbird depending mostly on wing motion while the Albatross, with its great wing spread, finds soaring flight most efficient. Soaring flight caused by air pulsations appears to be distinct from soaring flight resulting from rising air currents. Soaring flight in a rising air current is circular, except where the rising current is caused by a cliff or other obstruction. In fact a circular soaring flight may be taken as an indication of an ascending air current.

One of the unexplained features in the study of marked birds has been the small percentage of recaptures or returns in subsequent years of the smaller Canadian birds banded during migration at northern stations (19), (20), (21), (28). Apparently these birds, though they are reported as returning in subsequent years to their winter homes—for instance, White-throated Sparrows (*Zonotrichia albicollis*) at Thomasville, Georgia—must usually arrive in the south by different routes each year (22), (23).* That a quartering flight offers a favorable air movement condition is noted by Wetmore (22, page 55). In a letter to the writer dated October 28, 1927, Lynds Jones says, "I have noticed quartering flight a good many times where there was a stream of flying birds, such as the migration flights of Crows, Bluebirds, Killdeers, blackbirds, ducks, and particularly of Lapland Longspurs in central Iowa, when I lived at Grinnell prior to 1890." If this quartering flight is customary it is evident that the only chance of recapturing banded birds at the same place will come with similar winds in following years.

If the flight of the Lapland Longspur (*Calcarius lapponicus*) is quartering, then a flock of these birds approaching a winter storm would tend to turn to the right. As shown on the chart (Fig. 7) the constantly shifting winds, moving counter-clockwise, would tend to keep the flock in the storm area.

That disasters have occurred to large flocks of Lapland Longspurs is shown by the accounts of Roberts (24), who estimated the mortality on part of the area at 750,000; of Saunders (25); and of Swenk (26).

Storms of the winter type, according to Ward (27) move eastward with increasing intensity in the regions, the north central states, where these disasters to bird life have been observed. Under these conditions a heavy fall of wet, clinging snow would force larger birds to the ground and completely destroy most of the smaller birds.

The writer suggests experiments with homing pigeons and also with gliding and sailing airplanes as a means of increasing our knowledge of pulsating air currents and quartering flight. Such experiments may also increase the efficiency of the planes.

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